

Reproduction in captivity of the Central American bushmaster (*Lachesis stenophrys*, Serpentes: Viperidae), in Costa Rica

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In Costa Rica *Lachesis stenophrys* is the longest venomous snake reaching approximately a total length of 2.5 m. Its distribution is along the Caribbean versant of Nicaragua to western and central Panama (Campbell and Lamar, 2004), and in Costa Rica is found in tropical and subtropical rainforest on the Caribbean versant. It is an uncommon species even though in certain protected areas remains relatively common (Solórzano and Cerdas, 1986; Zamudio and Greene, 1997). The species of this genus are the only ones in the New World that lay eggs instead of giving birth to newborns with the possible exception of *Bothrocophias colombianus* (Savage, 2002; Campbell and Lamar, 2004; Solórzano, 2004).

The eggs are deposited in natural subterranean cavities and the burrows of other animals, with reported clutches of up to 18 eggs hatching in 75 – 90 days (Solórzano, 2004), although Chacón and Valverde (2004), report an incubation period of 105 – 108 days in captivity.

The reproductive cycle is seasonal, mating occurs in February and March, the eggs are deposited from June to August, and birthing takes place from August to October but sometimes in November (Chacón and Valverde, 2004). In captivity, females reach sexual maturity at approximately 1.6 m in total length and at about five years of age (Solórzano, 2004). Furthermore, there have been many fruitful efforts to maintain and breed *Lachesis stenophrys* in captivity (Boyer *et al.*, 1989; Ripa, 1994; de Souza, 2007).

Thus, we report a successful breeding of *Lachesis stenophrys* in captivity (*ex-situ*) in Costa Rica, with the main objective of provide venom for scientific purposes as well as study of biological behavior in conditions of captivity.

The terrariums in which the *Lachesis stenophrys* were housed have the following dimensions: 1.2 m (wide) x 2.4 m (long) x 0.9 m (tall); they have

a shelter that provides refuge to the snake, *ad libitum* water supply, and a log and rocks to facilitate the shedding of skin, and some large dry leaves. Different layers compose the substrate; the first layer is made of small stones and rocks, which work as filter and keep humidity inside the terrarium; then a thin layer of river sand or substrate, and at last a layer of large dry leaves. This substrate composition prevents the animals to be directly exposed to constant humidity, which could lead to severe ventral infections.

Additionally, two methods were used in order to provide a gradient temperature: a 75 W light bulb turned on during three hours per day in the morning, which is located at a corner of the terrarium; and a hot plate, which is turned on 24 hours per day, located at the opposite corner in the terrarium. These conditions provide an overall range of temperature of 21 – 33 °C. The relative humidity varies from 54% to 96% and depends on availability of water inside the terrarium and frequency of misting, as well as the environmental fluctuations and rain precipitation intervals.

The feeding process is voluntary by the snakes, there were no handling or forced-feeding techniques applied, which translates in low stress to the animals. An important feature seen in the wild is that this species tend to feed on small prey (Savage, 2002; Solórzano, 2004), which makes them a selective predator. In fact, smaller prey helps to avoid obesity and keep snakes in an active state whilst larger prey increase the lapse time of digestion and the snakes become less active. Furthermore, the feeding is performed with dead prey not frozen; and adult animals are fed every two weeks (15 days period time), with 90 g rats approximately. The snakes were fed once per week post mating season as well as after breeding in order to gain weight after breeding.

The animals selected for this study showed a range of total length for males of 183 – 193 cm, and

a weight range of 3400 to 4400 g. Regarding females, a range of total length of 181 – 196 cm and a weight range of 3300 to 3700 g were recorded. The deworming was conducted once a year with Farnenzol®, which include pirantel, fenbendazol and prazyquantel. In addition, the snakes were submitted to venom extraction processes five times per year.

We used five snakes for the entire reproduction process, one wild-caught male, one captive-born male (12 years old) and three captive-born females (12 years old). At the beginning of December until February, we put the wild-caught male together with each captive-born female, which is more efficient due to the quick response by the male who would aggressively begin to court the female. This behavior consists primarily of rough movements, the male rubbing his dorsal scales against the female's scales. This kind of behavior triggers a faster response by the female, stimulating it for mating.

Later, a pregnant snake became very active, looking for spots around the terrarium to lay eggs and searching for hot spots to thermoregulate (Figure 1A). Once the eggs were laid, they were transferred to a glass enclosure with the following dimensions: 60 cm (wide) x 45 cm (long) x 45 cm (tall). This enclosure presents features such as small plate with water; a solid base at the center of the enclosure which elevates the tray covered by a thin foam where the eggs are placed. A lid with 45° inclination angle to facilitate the water dropping at one ending of the lid and an air opening located at one side of the enclosure.

A water heater, which is placed inside the enclosure and an environmental heater provide the

warm in order to maintain constant humidity inside the enclosure, thus showing a range of temperature of 26 °C to 30 °C, whilst the range of relative humidity was 71% to 88%.

The mating season took place during December to February, laying eggs occurred during June, July and August; and hatching took place during September and October. An average of 9 ± 2 eggs laid (7 -13 eggs range), the average weight was 82 ± 0.2 g and a total length average was 7 ± 0.5 cm; whilst the newborn weighted 63.57 ± 9 g (45 – 70 g range), with a total length of 44.79 ± 3.8 cm (38 – 48 cm range) (Figure 1B). We recorded ovopositions of two females in the same year (2012), then ovopositions of three females next year (2013).

It is important to mention that the courtship of males can be very aggressive, in which the male dominates the female with rough movements, touching its scales against those of the female, surrounding the female's vent with its prehensile tail, moving its tail up and down, and rubbing all its body on the female.

De Souza (2007), showed that *L. muta rhombeata* displayed sexual activity after storms or strong raining and furthermore Boyer *et al.* (1989), showed that a drop in temperature and an increase in humidity triggers hormonal response in bushmaster females. In agreement, we observed that the sexual activity starts at the end of December in Costa Rica, when the temperature falls, and continues until March. An interesting point is that the animals (both sexes) fasted during the season of mating and breeding, which we found to be a good indicator of the sexual activity of the snakes. In contrast, Ripa (1994) found no sexual activity in *Lachesis stenophrys* fe-



Figure 1. (A) Female of *Lachesis stenophrys* coiled and displaying a protective posture with the eggs laid. (B) Newborn of *L. stenophrys* placed in the terrarium after weight and length measures were taken.

males despite the temperature/humidity changes. Instead, he found that the use of chemical secretion left by *L. melanocephala* pairs would trigger a sexual response. On the other hand, Solórzano (2004) showed that the mating season of *L. stenophrys* takes place during February and March and the females display a biannual reproductive cycle. Nevertheless, we had two consecutive breeding seasons by two different bushmaster females. Additionally, we found that isolation of females until shed their skins in mating season, and a later re-introduction of the male without removing the skin function as a sexual stimulus.

In conclusion, the timing of the breeding season, as well as when the eggs were laid and the newborns hatched are in concordance with those reported in literature (Ripa, 1994; Chacón and Valverde, 2004; Solórzano, 2004; de Souza, 2007). Finally, snakes born and maintained in captivity it is a major advantage in venom supply to research institutes, which will translate into knowledge in addition to the improvement in the manufacture of antivenoms.

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